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GAMMA RAY PROPERTIES FROM ^{70}AS NUCLEUS

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ABSTRACT

Multipole mixing ratios **(** δ **)** for gamma transition populated in ^{70}As from **^{70}Ge (p,nγ)** reaction have been studied by least square fitting method (**LSF**)**,** also transition strength **$[M(EL,ML]^2$** for pure gamma transitions have been calculated taking into accunte the mean life time for these levels **.**

KEYWORDS: Multipole Mixing Ratios, Least Square Fitting Method, Angular Distribution, **^{70}Ge** (**p,nγ**)**,** Transition Strength, Gamma Width

INTRODUCTION

The energy levels of **^{70}As** have been studied from **^{70}Se** by **β^+**- decay and **(p,nγ)** reaction by Ten Brink et.al **[1,2].**

Filevichctal also study **^{70}As** nuclei from heavy-ion reactions **[3].**the δ - mixing ratios of γ-transitions from levels of **^{70}As** isotopes were calculated using a_2-ratio and constant statistical tensor **CST** - **Method** by taghreed **[4].** Podolyok et.al have been studied excited levels in **^{70}As** from **(p,nγ) ,** were the proton energy is varied between **7.59** and **8.7** MeV**,** energies and relative intensities of **113** (among them **60** new)^{70}As excited levels**,** also determined **γ -**ray branching and mixing ratios, levels and parity values **[5] .**

The aim of the present work is to determine the multipole mixing ratios δ of **γ -**ray for **^{70}As** from **(p,nγ)** reaction by using **LSF–Method** and to study the transition strength of **γ -**ray for pure electric and magnetic equaduapole emission in **^{70}As** isotopes **.**

Data Reduction & Analysis

Levels with certain $\mathbf{J_i}$ values might have no pure **γ**-transition or transition considered to be pure **.** the statistical tensor $\rho_2(J_i)$ for such levels can not be calculated and hence the δ - values of mixed transition from such levels can not be determined by the **CST-Method** it also happens that a level with certain $\mathbf{J}_i$- values has only one pure **γ**- transition or considered to be pure **γ**- transition whose **a_2- coefficient** is not accurately measured in which case , the statistical tensor $\rho_2(J_i)$ calculated for that levels shall be inaccurate also**.** the **LSF**- **Method** was there for **,** suggested to estimate $\rho_2(J_i)$ for all $\mathbf{J_i}$ –values . in this method, the $\rho_2(J_i)$ values calculated for levels with different $\mathbf{J_i}$ –values are computer fitted to a polynomial series of the form**:**

$$\rho_2(J_i) = \sum \boldsymbol{B_x} \boldsymbol{J}^x \qquad (1)$$

with n= **1,2,3,4** and **5**, using the least square fitting program that was written in the present work in matlab language to determine the $\mathbf{B_X}$ parameters for all **n**-values and the $\mathbf{R^2}$ –values for each n. the set with best $\mathbf{R^2}$ values was

then used to calculate the $\rho_2(J_i)$ values for all **J**i values **.** the obtained values of $\rho_2(J_i)$ are then used to calculate the **δ** – values for all **γ**-transition whose angular distribution have been measured **[4,5]** An additional calculation was performed for each **γ**- ray transition it is the calculation of transition strength and total gamma width as follows**:**

Skerka et.al **[6]** has shown that, the partical width of **γ**- ray transition from an intial state with spin $\mathbf{J_i}$ to final state with spin $\mathbf{J_f}$,may be represented by the following**:**

$$\Gamma_\gamma \ell = \frac{8\pi[(\ell+1)]}{\ell[(2\ell+1)!]^2}\left[\frac{E_\gamma}{\hbar c}\right]^{2\ell+1} B(L) \qquad (2)$$

Where

ђ : Dirac constant = $\frac{h}{2\pi}$, h= plank constant

c: speed of light

$\mathbf{E_\gamma}$ **:** Gamma ray energy

ℓ **:** Angular momentum of the γ – transition, $\ell \neq 0$

B(L) : Reduced transition probability

The wisskopf single-particle reduced transitions probability is defined in Ref**.[7]** by **:**

$$B(EL)\,(W.u) = \frac{t^{\gamma}_{½}\,(EL)\ \ sp}{t^{\gamma}_{½}\,(EL)_{exp}}$$

$t^{\gamma}_{½}$: partical half life for **γ** – ray transition .

If the total width *is* $\Gamma_\gamma = \sum \Gamma_{\gamma i}$ (4)

Then $\Gamma_\gamma T = \hbar = 0.65822X10^{-15}\ ev.s$ (5)

Where **T** is the mean life time of the initial state = $\frac{t_{½}}{ln2}$ (6)

The **γ**- ray transition strength $\mathbf{[M]^2}$ is defined as **[6]**

$$[M]^2 = \frac{\Gamma_\gamma}{\Gamma_{\gamma w}} \qquad (7)$$

$\mathbf{\Gamma_{\gamma w}}$**=** width in Weiss Kopf unit

By using single partical model, Weisskopf derived the following relation for

$\Gamma_{\gamma w}\ [(EL)]$ *and* $\Gamma_{\gamma w}\ [(ML)]$ *:*

$$\Gamma_{\gamma w}\ (EL) = 6.7469x10^{-11} A^{2/3} E_\gamma^{\,3} \qquad (8)$$

$$\Gamma_{\gamma w}\ (ML) = 2.0722x10^{-11}\ E\gamma^{3} \tag{9}$$

Where **A**: mass number.

E_γ in keV, $\Gamma_{\gamma w}$ in eV.

For γ –transitions with mixed mulipolarities **L** and **L+1** and by theoretical calculation from Ref**.[7]** substuting mixing ratio δ in eq **.(5&6)**

$$\delta^2 = \frac{\Gamma(L+1)}{\Gamma(L)} \tag{10}$$

Where

$$\Gamma(L) + \Gamma(L+1) = \Gamma_\gamma \tag{11}$$

partial width of each **γ**- ray can be calculated as follows **[8]:**

$$(\Gamma_{\gamma L} = BRi\ x\ \Gamma_\gamma \tag{12}$$

BR_i is the branching ratio of **(γ_i)** which can be calculated as in Ref**. [9]** from **:**

$$BR(\gamma i) = \frac{I_{\gamma i}}{I_{tot}}\ x\ 100\% \tag{13}$$

$I_{\gamma i}$ = the relative intensity of γ_i

$I_{tot} = \sum I_i$

Also the square of the mixing ratio **δ^2**, may be defind as follows**[9]**

$$\delta^2 = \frac{I_{\gamma i}(L+1)}{I_{\gamma i}(L)} \tag{14}$$

$$I_\gamma(L) + I_\gamma(L+1) = I_\gamma \tag{15}$$

For pure **EL, ML** transition **δ =0** and hence:

$$\Gamma(E1)\ or\ \Gamma(E2) = \Gamma_\gamma \tag{16}$$

And the transition strength of this transition can be calculated by using eq.**(6)**, the corresponding **$\Gamma_{\gamma w}(E_2)$** Values calculated for the transitions ,so that eq. **(8,9)** can then used in the form of

$$[M\ (E1)]^2 = \frac{\Gamma(E1)_{exp}}{\Gamma(E1)\ w.u} \tag{17}$$

$$[M\ (Ml)]^2 = \frac{\Gamma(M1)_{exp}}{\Gamma_{\gamma w}(M1)_{w.u}} \tag{18}$$

RESULTS & DISCUSSIONS

Result for δ – Values Calculated by LSF Method

The weighed average of $\rho_2(J_i)$ presented in table **(1),(2)** were computer fitted as mentioned previously **.**

The fitting equation was as follows

$$\rho_2(J_i) = -0.09 - 0.54135\, J_i + 0.36578\, J^2_i - 0.12615\, J^3_i - 0.013623\, J^4_i \quad (20)$$

The $\rho_2(J_i)$ values calculated for each **Ji** as follows

$\rho_2(1) = -\ 0.3844$

$\rho_2(2) = -\ 0.5135$

$\rho_2(3) = -\ 0.7436$

$\rho_2(4) = -1.0144$

$\rho_2(5) = -\ 0.9383$

the statistical tensor coefficient $\boldsymbol{\rho_k(J_i,M_i)}$ are constant for each $\mathbf{J_i}$ values then according to [10]:

$$\rho_k(J_i) = \sum_{\substack{m_i=0 \\ \text{or } m_i=\frac{1}{2}}}^{J_i} \rho_k(J_i m_i)\, P(m_i) \quad (21)$$

the statistical tensor $\boldsymbol{\rho_k(J_i)}$ would also be constant for level with the same $\mathbf{(J_i)}$ value so eq.**(21)** can be used to calculate multipole mixing ratio for **γ** – transition for each levels where $\mathbf{(J_i)}$ is constant by using $\boldsymbol{\rho_k(J_i)}$ values as follows[10]**:**

$$a_2(J_i\text{-}J_f) = \rho_2(J_i)\, F_2(J_i\, J_f\, \delta) \quad .(22)$$

Where $\mathbf{F_2\ (Ji\ J_f\ \delta)}$ is parameters included information about angular momentum and mixing ratio and given by [11]

$$F_2(Ji\, J_f\, \delta) = \frac{F_2(J_fL_1L_1J_i) + 2\delta\, F_2(J_fL_1L_2J_i) + \delta^2 F_2(J_fL_2L_2J_i)}{(1+\delta^2)} \quad (23)$$

Where : The F_2 values were represented in Ref. [12]

$$L_1 = |J_i - J_f| \neq 0 \quad (24)$$

$$L_2 = L_1 + 1 \quad (25)$$

Sub.eq .(23) in eq. (22) the result as follows:

$$a_2(1\text{-}1) = \rho_2(1)\ \frac{-0.35355-2.12134\,\delta - 0.35355\,\delta^2}{(1+\delta^2)} \tag{26}$$

$$a_2(1\text{-}2) = \rho_2(1)\ \frac{0.07071+0.94868\,\delta + 0.35355\,\delta^2}{(1+\delta^2)} \tag{27}$$

$$a_2(2\text{-}1) = \rho_2(2)\ \frac{0.41833 - 1.87084\ \delta - 0.29881\,\delta^2}{(1+\delta^2)} \tag{28}$$

$$a_2(2\text{-}2) = \rho_2(2)\ \frac{-0.41833 - 1.22476\,\delta + 0.12806\ \delta^2}{(1+\delta^2)} \tag{29}$$

$$a_2(3\text{-}2) = \rho_2(3)\ \frac{0.34641-1.89738\,\delta - 0.12372\,\delta^2}{(1+\delta^2)} \tag{30}$$

$$a_2(3\text{-}3) = \rho_2(3)\ \frac{-0.43301- 0.86602\,\delta + 0.22682\,\delta^2}{(1+\delta^2)} \tag{31}$$

$$a_2(3\text{-}4) = \rho_2(3)\ \frac{0.14434 + 1.44338\,\delta + 0.30929\,\delta^2}{(1+\delta^2)} \tag{32}$$

$$a_2(4\text{-}2) = \rho_2(4)\ \frac{-0.44770 - 1.05944\,\delta - 0.47009\ \delta^2}{(1+\delta^2)} \tag{33}$$

$$a_2(4\text{-}3) = \rho_2(4)\ \frac{0.31339 - 1.88036\,\delta - 0.04477\ \delta^2}{(1+\delta^2)} \tag{34}$$

$$a_2(4\text{-}4) = \rho_2(4)\ \frac{-0.43875 - 0.67082\,\delta + 0.26455\,\delta^2}{(1+\delta^2)} \tag{35}$$

$$a_2(5\text{-}4) = \rho_2(5)\ \frac{0.29439 - 1.86190\,\delta + 0.00000\,\delta^2}{(1+\delta^2)} \tag{36}$$

Results for Transition Strength

The transition strength $[\mathbf{M(EL,ML)}]^2$ for γ- transitions from excited levels to the ground levels that produced by pure electric or magnetic quadrupole transitions for $^{70}\mathbf{A_S}$ isotope represented in figure **1** have been calculated as follows**:**

Mean life time **τ** for excited level calculated by using eq. **(5)** half life times **$t_{1/2}$** related to these levels were present to gather with relative intensities for **γ** –transition measured by Ref **.[5].**

The total gamma width **Γ_γ** calculated by using eq**.(4)** table **(3)** represent these values**.**

- Using total gamma width and relative branching ratios in order to calculate partial gamma width **Γ (E_2) & Γ (M_1)** by using eq. **(11).**
- Using eq**.(8 & 9)** the partial gamma width **Γ (E_2) & Γ (M_1)** in **w.u** were calculated for each gamma transition
- Table **(4)** represent the transition strength values **$[M(EL,ML)]^2$** for each **γ** – ray transition were calculated by using eq**.(15).**

CONCLUSIONS

In the present work, The LSF –Method has been used to calculate the multipole mixing raitios of γ- transition from level in ^{70}As and also transition strength pure γ –ray transition also calculated. The reselts are in general, in good agreement with those obtained previously CST (1) & CST(2) and that from other refrenceses. Ths confirms that the present Method is good as other Methods and rather simple.

REFERENCES

1. B. O. ten Brink, R. D. Vis, A. W. B. Kalshoven and H.verheul, Z., (1974), Phys. 270, 83.
2. B. O. ten Brink, J. Akkermans, P. Van Nes and H. Verheul, (1979), Nucl. Phys. A330, 409.
3. A. Fi Levich, M. Behar, G. Garcia Bermudez, M. A. J. Mariscotti, E.der Matesian, P. Thieberger, (1978), Nucl. Phys. A309, 285.
4. Tagreed A. J. Younis, (2005); Multipole Mixing Ratios of γ-Rays from ^{56}Fe(n,n′γ)^{56}Fe,^{70}Ge(p,nγ) ^{70}As and $^{142\text{-}150}$Nd(n,n′γ) $^{142\text{-}150}$Nd Reactions. 5- Z. S. Poda lak, T. Fenyes, J. Timar, (1995), Nucl. Phys. A584:60.
5. Skerka S. J, Hertal. J. and Retzschaidt, (1966), Nucl. Data. A2, p.341.
6. Forsten R. B. and shirlay V.S, (1999), table of isotopes, 8th edition
7. Kibed T., Spear R. H., (2005), Atomic Data & Nucl. Data tables, 89:77.
8. Andvejtscheef W., Schilling K. D. & Marfross p., (1975), Atomic Data, Nucl. Data tables, 16:515.
9. Poletti, A. R., and Warburton, E.K., (1965), Phys. Rev. 137, B595.
10. Yamazaki T., (1967); Nucl. Data, Section A3, 1.
11. Al-Zuhairy M.H.M.,(2002); multipole mixing ratios of Gamma Ray from the Heavy ion Reactions by using constant statistical Tensor Method, Ph.D. Thesis University of Baghdad.
12. Zs. Podolyak et al. (1995), Nuclear physics A 584, 60-83.

APPENDICES

بطريقة مطابقة المربعات ^{70}**Ge** ^{70}As المتولدة في التفاعل (p,n$_\gamma$) ^{70}As *الخلاصة* تم في هذا البحث حساب نسب الخلط (δ) لانتقالات اشعة كاما في النواة بالاعتماد على حساب معدل العمر للمستوي المتهيج والشدة النسبية لاشعة كاما المنتقلة . وان النتائج التي تم وكذلك تم حساب قوى الانتقال(LSF)الدنيا الحصول عليها كانت متوافقة مع النتائج المنشورة سابقا .

Table 1: Multipole Mixing Ratios (δ) for Gamma Transition Populated in AS by Using Least Square Fitting

E_i (KeV)	E_γ (KeV)	$J_i^\pi - J_f^\pi$	a_2 a_4 [9]	δ [9]	δ CST(1) [4]	δ CST(2) [4]	δ LSF(P.W)
81.52	49.45	$1^{+}-2^{+}$	-0.062(49) -0.036(61)	0.12(31)	....	$0.07^{+0.15}_{-0.13}$ $-4.4^{+10}_{-1.9}$	$0.07^{+0.13}_{-0.14}$ $-4.4^{+6.2}_{-1.7}$
167.72	86.19	$2^{+}-1^{+}$	-0.186(64) -0.012(60)	0.03(3)	-0.02(10) $-2.8^{+0.9}_{-0.6}$	0.03(7) -2.9(7)	0.03(7) $-2.9^{+0.7}_{-0.6}$
234.79	202.66	$1^{+}-2^{+}$	0.142(58) 0.125(46)	-0.01(27) -------	-- --------	Imajenary roots	Imajemary roots
	163.18	$1^{+}-1^{+}$	-0.126(106) -0.278(115)	$0.28^{+0.62}_{-0.28}$	---------	$-0.36^{+0.40}_{-0.19}$ $-2.7^{+3.3}_{-1.4}$	$-0.36^{+0.27}_{-0.16}$ $-2.7^{+2.3}_{-1.1}$
326.68	293.63	$2^{+}-2^{+}$	0.304 (90) 0.024(78)	0.15 (4) ---------	$0.34^{+7}_{-0.31}$ $1.1^{+1.0}_{-7}$	$0.16^{+0.20}_{-0.17}$ $1.5^{+0.8}_{-0.6}$	$0.16^{+0.24}_{-0.16}$ $1.5^{+0.7}_{-0.5}$
	244.10	$2^{+}-1^{+}$	-0.179(69) -0.003(70)	0.03(3)	- 0.01 (11) $-2.6^{+1}_{-0.7}$	0.04(7) $-2.9^{+0.9}_{-0.6}$	0.04 (66) $-2.9^{+0.9}_{-0.5}$
328.64	296.64	$1^{+}-2^{+}$	-0.040(87) -0.043 (67)	-0.19 (24)	....	$0.03^{+0.25}_{-0.27}$ $-3.8^{+61.2}_{-2.1}$	$0.03^{+0.27}_{-0.23}$ $-3.8^{+37.4}_{-2}$

	247.11	1'-1'	-0229(166) -0.264(174)	-0.16 (40) ------------	------------	$-0.62^{+?}_{-0.43}$ $-1.6^{+3.7}_{-?}$	$-0.62^{+?}_{-0.36}$ $-1.62^{+3.2}_{-?}$
	160.89	1'-2'	-0.091(59) -0.086(62)	0.05 (28) ------------	------------	$0.17^{+0.24}_{-0.22}$ only	$0.17^{+0.17}_{-0.16}$ Only
383.32	301.80	2'-1'	-0.165 (53) 0.010(54)	0.03 (3) ------------	0.01 (8) $-2.7^{+0.9}_{-0.5}$	0.05(6) $-3.6^{+0.7}_{-0.5}$	0.05(5) $-3.1^{+0.6}_{-0.5}$
	148.57	2'-1'	-0.051 (236) 0.027(155)	0.14 (7)	$0.15^{+0.33}_{-0.31}$ only	$0.16^{+0.32}_{-0.24}$ only	$+0.261^{0.16}_{-0.24}$ only
390.13	223.42	3'-3'	0.131(106) -0.116 (115)	-0.21 (8) ------------	-0.28(14) $2.5^{+1.4}_{-0.7}$	$-0.26^{+0.16}_{-0.14}$ $2.4^{+1.4}_{-0.7}$	- 0.26 (0.14) $2.4^{+1.3}_{-0.7}$
485.32	318.60	4'-3'	-0.285 (49) -0.047 (38)	0.013 (14) ------------	0.00 (4)	0.02 (4) $-5.8^{+1}_{-0.8}$	0.02 (2) $-5.8^{+1}_{-0.8}$
508.84	476.75	3'-2'	-0.271 (133) 0.116(99)	-0.05 (4) ------------	0.01 (10) $4.2^{+2.9}_{-1.3}$	-0.01 (11) $-3.9^{+2.6}_{-1.3}$	-0.01 (9) $-3.9^{+2.3}_{-1.2}$
539.99	458.48	2'-1'	-0.400(104) -0.005 (103)	$-0.17^{+0.12}_{-0.19}$ ------------	$-0.40^{+?}_{-0.28}$ $-1.1^{+0.8}_{-?}$	$-0.22^{+0.2}_{-0.14}$ -1.5(6)	$-0.22^{+0.2}_{-0.13}$ -1.5 (5)
566.53	81.19	5'-4'	-0.413 (104) +0.003(103)	-0.08 (4) ------------	------------	-0.05 (9) $-4.1^{+2.5}_{-1.2}$	-0.08 (6) $-4.2^{+1.4}_{-1}$
571.96	539.92	2'-2'	0.284 (64) -0.056 (71)	0.11 (8) ------------	$0.26^{+?}_{-0.22}$ $1.2^{+0.8}_{-?}$	$0.12^{+0.13}_{-0.12}$ 1.7(6)	$0.12^{+0.13}_{-0.12}$ $1.7^{+0.5}_{-0.4}$
581.61	413.89	1'-2'	-0.252 (98) -0.267 (104)	0.05 (34) ------------	------------	$0.84^{+?}_{-0.48}$ $2.3^{+19.5}_{-?}$	$0.84^{+?}_{-0.49}$ $2.3^{+17.7}_{-?}$
625.21	235.10	4'-3'	-0.328 (135) -0.180 (137)	0.03 (6) ------------	-0.02(9) $-4.7^{+3.1}_{-1.4}$	-0.01 (8) $-5.1^{+3.3}_{-1.5}$	-0.01 (7) $-5.1^{+3}_{-1.4}$
641.84	474.12	3'-2'	-0.273 (186) -0.090 (185)	0.03 (8) ------------	0.01 (13) $-4.2^{+4.8}_{-1.6}$	-0.01 (18) $-3.9^{+4.6}_{-1.6}$	$-0.01^{+0.14}_{-0.13}$ $-3.9^{+4.1}_{-1.5}$
698.86	315.53	3'-2'	-0.301 (99) -0.061 (76)	-0.01 (3) ------------	-0.01 (8) $-3.9^{+1.8}_{-1}$	-0.03 (9) $-3.6^{+1.7}_{-1}$	-0.03 (7) $-3.6^{+1.2}_{-0.8}$
772.28	286.96	3'-4'	-0.169 (173) 0.076 (172)	0.07 (11) ------------	$0.04^{+0.15}_{-0.13}$ only	0.06 (17) Only	0.06 (16) Only

Table 2: Multipole Mixing Ratios of γ-Transitions Populated in^{70}As by Using Aproximated Values from Ref.[9]

E_i(KeV)	E_γ(KeV)	J_i^π -J_f^π	a_2 a_4 [9]	δ Ref[9]	δ CST(P.W)	δ LSF(P.W)
81.52	49.45	2^+- 2^+	-0.052 (49) -0.036 (51)	≈-0.40	$-0.42^{+23.0}_{-0.09}$	-0.42(8) Only
		3^+- 2^+	-0.052 (49) -0.03 (51)	≈+0.16	+0.14(4) $-10^{+5.03}_{-2.58}$	0.14 (3) $10^{+5.03}_{-2.6}$
234.73	2.2.66	3^+- 2^+	+0.142 (58) +0125 (46)	≈+19.08	$0.3^{+0.03}_{-0.06}$ Only	$0.3^{+0.03}_{-0.06}$ Only
325.65	293.63	3^+- 2^+	0.304 (90) 0.024 (75)	≈+0.45	0.43(9) 6.2^{+5}_{-4}	0.43(9) 6.2^{+5}_{-2}
383.32	148.57	1^--1^+	-0.051 (235) +0.027 (185)	≈-0.34	$-0.24^{+?}_{-0.3}$ $-4.1^{+12.8}_{-?}$	$-0.24^{+?}_{-0.3}$ $-4.1^{+12.8}_{-?}$
	301.80	1^--1^+	-0.165 (53) +0.010 (54)	≈-0.62	$-0.44^{+0.14}_{-0.1}$ $-2.3^{+0.7}_{-0.6}$	$-0.44^{+0.16}_{-0.1}$ $-2.3^{+0.7}_{-0.6}$
390.13	223.42	2^+-3^+	+0.131 (106) -0.116 (115)	≈-0.47	$-0.38^{+?}_{-0.25}$ $-1.9^{+1.3}_{-?}$	$-0.34^{+?}_{-0.21}$ $-1.9^{+1.3}_{-?}$
		5^+-3^+	+0.131 (106) -0.116 (115)	≈-8.14	$-0.3^{+0.1}_{-015}$ $-4.6^{+4.9}_{-1.7}$	$-0.3^{+0.1}_{-015}$ $-4.6^{+4.9}_{-1.7}$
485.32	318.60	1^--3^+	-0.285 (49) -0.047 (38)	≈+2.14	Imajenary Roots	Imajenary Roots
		2^--3^+	-0.285 (49) -0.447 (38)	≈+0.32	5.8^{+5}_{-2} $0.35^{+0.1}_{-0.08}$	5.8^{+5}_{-2} $0.35^{+0.1}_{-0.08}$
		3^--3^+	-0.285 (49) -0.047 (38)	≈-1.15	$-1.2^{+?}_{-1.1}$ $-4.3^{+4.3}_{-?}$	$-1.2^{+?}_{-1.1}$ $-4.3^{+4.3}_{-?}$
566.53	83.39	2^- -4^-	-0.413 (104) +0.003(103)	≈+1.80	Imajenary Roots	Imajenary Roots
		2^+-3^+	-0.28 (135) -0.180(137)			

		3^--4^-	-0.413 (104) +0.003 (103)	≈+0.27	$0.29^{+0.15}_{-0.11}$ $5.6^{+9.5}_{-2.4}$	0.13(1) $5.6^{+7.8}_{-2.3}$
571.95	539.90	3^+-2^+	+ 0.284 (64) -0.05(71)	≈+0.42	$0.4^{+0.07}_{-0.05}$ $7^{+3.7}_{-2}$	$0.40^{+0.07}_{-0.05}$ $7^{+3.7}_{-2}$
		4^+-2^+	+ 0.284 (64) +-0.05(71)	≈-11.43	$-0.16^{+0.07}_{-0.06}$ $-5.4^{+2.85}_{-1.4}$	$-0.16^{+0.07}_{-0.06}$ $-5.4^{+2.8}_{-1.4}$
625.21	235.10	1^+-3^+	-0328 (135) -0.180(137)	≈ +2.14	Imajenary Roots	Imajenary Roots
		2^+-3^+	-0328 (135) -0.180 (137)	≈ +0.21	$0.44^{+?}_{-0.24}$ $4^{+34}_{-?}$	$0.4\ 4^{+?}_{-0.1}$ $4^{+34}_{-?}$
		3^+-3^+	-0328 (135) -0.180(137)	≈ -4.70	$2^{+?}_{-1.17}$ $2.1^{+23.5}_{-?}$	$2^{+?}_{-1.2}$ $2.1^{+23.5}_{-?}$
641.84	474.12	1^+-2^+	-0.273 (186) -0.090 (188)	≈ +1.33	Imajenary Roots	Imajenary Roots
		2^+-2^+	-0.273 (186) -0.090 (188)	≈ -0.82	Imajenary Roots	Imajenary Roots
698.86	315.53	1^--2^-	-0.301 (99) -0.061(76)	≈ +1.33	Imajenary Roots	Imajenary Roots
		2^--2^-	-0.301 (99) -0.061(76)	≈ +1.13	Imajenary Roots	Imajenary Roots
772.28	286.96	2^--4^-	-0.169 (173) +0.076 (172)	≈ +0.52	$0.5^{+0.6}_{-0.3}$ Only	$0.5^{+0.6}_{-0.3}$ Only
		4^--4^-	-0.169 (173) +0.076 (172)	≈ -0.75	$-0.81^{+0.59}_{-0.28}$ Only	$-0.81^{+0.59}_{-0.28}$ Only
		5^--4^-	-0.169 (173) +0.076 (172)	≈ +0.04	$0.05^{+0.2}_{-0.09}$ Only	$0.06^{+0.1}_{-0.1}$ Only

Table 3: Mean Life Time (τ_m) and Total Gamma Width (Γ_γ) for Levels of ^{70}As

E_i(KeV)	E_f(KeV)	E_γ(KeV)	$10^{-9}{}_s\tau$ ×	J_i^π -J_f^π	I γ	(EL,ML) $\Gamma_\gamma \times 10^{-9}$ eV
167.7	81.56	86.25	< 4.3	2^+ -1^+	35(4)	M1> 39.4±4.8
234.8	32.07	202.73	138528±4329	1^+ -2^+	100(1)	M>0.004±0.0001
325.7	81.56	244.14	< 4.3	2^+ -1^+	100(3)	M1> 76±3.2
328.7	167.7	160.79	< 4.3	1^+ -2^+	100(7)	M1>71.69±9.85
383.4	81.56	301.9	< 4.3	2^+ -1^+	100(4)	E1>119±12
483.3	166.7	318.6	8± 0.721	4^+ -3^+	100(5)	E1>44.39±5.05
581.6	167.7	413.91	< 4.3	1^+ -2^+	100(3)	M1>57±3
641.8	167.7	474.1	< 4.3	3^+-2^+	100	M1>152
698.8	383.4	315.5	< 1.4	3^+-2^+	100	M1>470

Table 4: The Transition Strength, $[M(EL, ML)]^2$ for ^{70}As Nucleus

E_γ (KeV)	J_i^π -J_f^π	B.R [5]	(EL,ML) $\Gamma 10^{-9}$ eV ×	w.u(EL,ML) ΓeV 10^{-9}×	$\lvert M(EL, ML)\rvert^2$ w.u.10^{-6}
86.25	2^+ -1^+	25.9 ± 3.1	M1 > 39.4 ±4.8	13474	> 2924 ± 356
202.73	1^+ -2^+	91.7 ± 1.9	M1 0.004 ± 0.0001	174973.9	0.0249 ± 0.009
244.14	2^+ -1^+	50 ± 2.12	M1 > 76 ± 3.2	305587.8	> 248.7 ± 10.4
160.79	1^+ -2^+	47.1 ± 6.4	M1 > 71.69 ± 9.85	87296.4	>821.3 ± 112.9
301.9	2^+ -1^+	78.7 ± 8.0	E1 > 119 ± 12	31780711.2	> 3.744 ± 0.377
318.6	4^+ -3^+	54.1 ± 3.7	E1 44.39 ± 5.05	37351804.4	1.188 ± 0.135
413.91	1^+ -2^+	38.0 ± 2.4	M1> 57 ± 3	1489145.2	>38.27 ± 2.01
474.1	3^+-2^+	100	M1> 152	2237840.6	>67.92
315.5	3^+-2^+	100	M1> 470	659503.92	>712.6

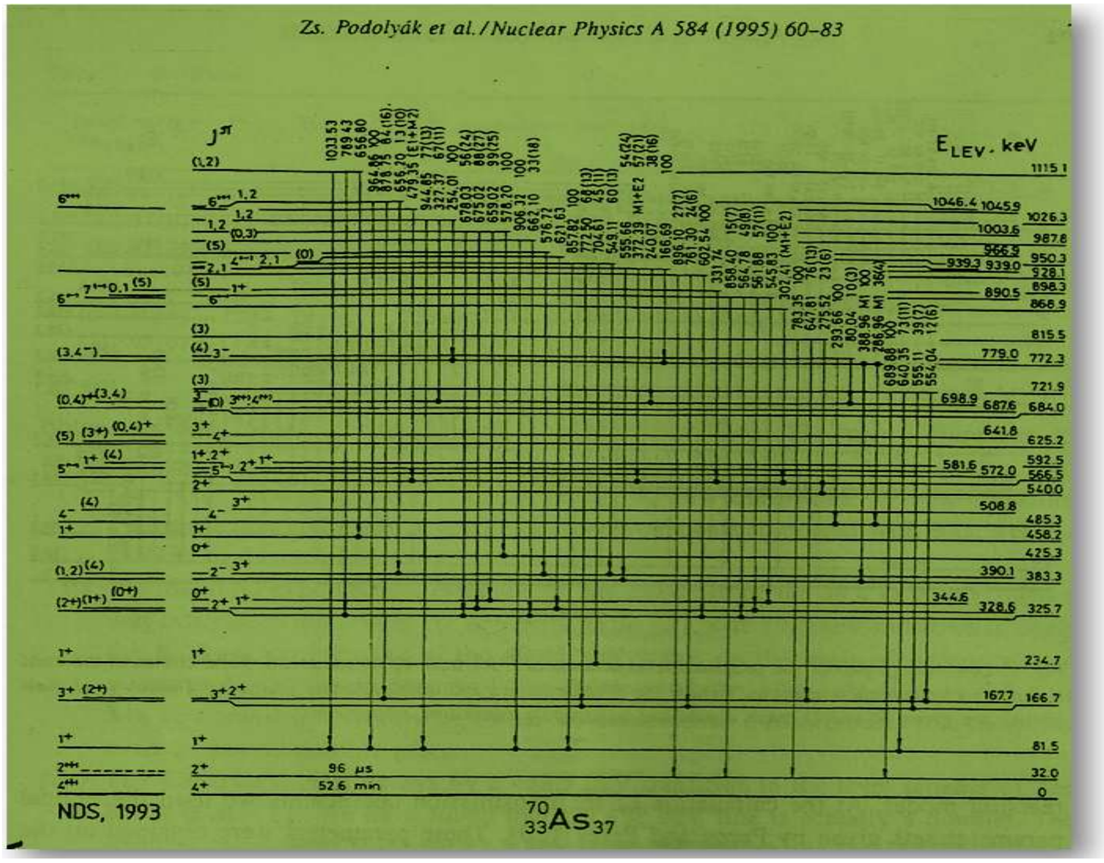

Figure 1: High Energy Part of the Proposed Level Scheme of ^{70}AS Adopted of the Nuclear Data Sheets Evaluatio Are Shown on the Left Side, which Contain Also the High-Spin States, Excited in Heavy –Ion Reaction.[13]